ON THE ANTHROPIC PRINCIPLE IN THE MULTIVERSE: ADDRESSING PROVABILITY AND TAUTOLOGY

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ABSTRACT

In this *Letter* we examine the Multiverse theory and how it relates to the Anthropic Principle. Under the supposition of Eternal Inflation, the String Theory Landscape (STL) has reinvigorated the discussion of the Anthropic Principle. The main premise being that the fundamental constants of our Universe are not necessarily of any fundamental physical importance, rather that the specific values are requisite for intelligent life to arise, and hence, for intelligent life to measure such constants. STL predicts a multitude of other meta-stable Universes with fundamental constants different than our own, possibly hinting at some intrinsic *specialness* of human life. We develop a theoretical framework to prove whether, (1) the Universe we observe must be consistent with the existence of observers, (2) the principle is only ontological in nature, or (3) if the Anthropic Principle itself is simply a tautology.

Subject headings: *A*nthropic *P*rinciple: *R*elativity — *I*nflation — *L*emaître *F*ractals — *O*bservations — *O*ntological *L*aws — *S*upersymmetry

1. INTRODUCTION

Is there a peculiar specialness to our Universe with regard to the existence of intelligent life? Philosophers have long pondered whether or not the Universe is "fine tuned" to accomodate such conscious beings. This is, in the most general sense, what is known as *The Anthropic Principle*. It can be considered in direct contradiction to the Copernican Principle (or the Cosmological Principle) that postulates that man does not occupy a privileged position in the Universe (under this principle, if we observe that the Universe is isotropic then it can be easily shown that the Universe is homogeneous). More specifically, the Earth is not the center of the Universe, and therefore, by definition, *you* are not the center of the Universe. This can also be extended to the *Mediocrity Principle* which argues that there is nothing unique about the Earth or even us as humans (see Zaius 1968). Furthermore, it has also been frequently proposed (e.g., Descartes) that the Anthropic Principle is a circular (or tautological) argument, and, in addition, since all other Universes in the Multiverse are inaccesible to us, this discussion is therefore meaningless. Until recently, most physicists would most likely shy away from addressing the Anthropic Principle in any scientific body of work. However, recent cosmological unravellings have made this subject unavoidable. Thus, the fundamental question to then pursue is: do we observe the Universe as it is simply because only observers like ourselves exist in such a Universe?

Despite precision measurements from the Cosmic Microwave Background and large scale structure (LSS) confirming the homogeneity of the Universe, the Anthropic Principle is not necessarily invalidated. A consequence of both String Theory and Cosmic Inflation (more specifically, Eternal Inflation) is the existence of an infinite number of possible Universes. Given this "Multiverse" scenario, we can redefine the problem. It may be plausible to assume that the fundamental constants need to have almost the exact values they do to give rise to life as we know it. Furthermore, cosmological paramaters,

like Ω, need to be tuned to incredibly high precision to result in a Universe that is not too "diluted" or too "overweight". However, the Multiverse implies that these constants will be different for every "pocket universe". In this paper, we form, from first principles, mathematical relations that attempt to infer the probability that we as humans matter in the Multiverse.

2. THEORETICAL FRAMEWORK

In the following sections we lay out our theoretical framework for calculating whether or not we are of any significance in a seemingly void, indifferent, and desolate Universe(s). We note that we do not subdivide our investigation to consider more specific versions of the Anthropic Principle, like the Weak[1] and Strong versions.

The Conditional Relations for the Anthropic Principle model (Model 1) assumes the favored concordance ΛCDM paradigm, simplified predictions from *The String Theory Landscape* (STL), and assumptions about the Multiverse from Eternal Inflation to calculate the likelihood that we matter, which is not at all arrogant endeavor. We now lay out a simple theoretical approach to estimate the magnitude of the importantness of our intelligent species.

We first take a standard envelope and turn it over. We then start to write down math on the back of it that we think relates to probabilistic arguments relevant to the Anthropic Principle. We will assume that there are $\sim 10^{200}$ meta-stable Universes comprising the Multiverse allowed by STL[2]. Let us also assume that the fundamental constants in each of these $\sim 10^{200}$ Universes are different from ours, though their vacuum energy densities may be somewhat similar. Thus, life may certainly exist in this multitude of Universes, but we argue that it will not be remotely like ours (see Figure 1). We also now know, to great accuracy, that our Universe is ~ 6000

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[1] We strongly advise not using the word "weak" when coming up with a Principle.

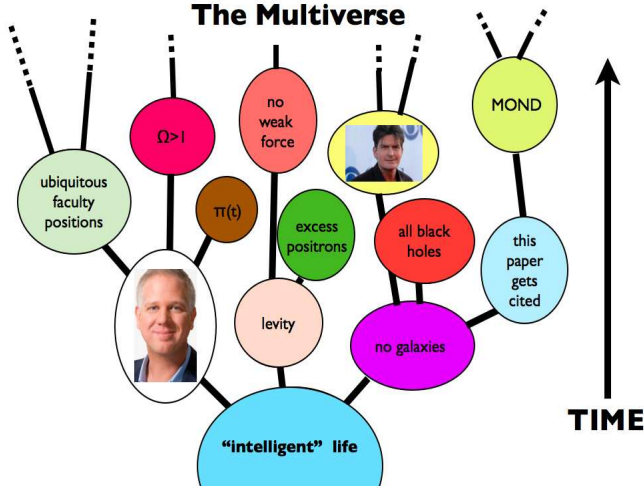[2] This may or may not have been "borrowed" from a recent talk by Alan Guth.

FIG. 1.— Cartoon schematic of the Multiverse. We inhabit one of a multitude of meta-stable Universes. Eternal inflation predicts that these "pocket universes" will have fundamental constants different than ours. Hence, though there may be other forms of life, we do not expect them to remotely resemble the intelligent life in our own Universe. Image is to scale.

years old (± 13.7 billion years), and let us take the upper limit. Since humans have been around $\sim 5999\frac{360}{365}$ years, this requires that the current epoch is really the only time that mankind could have existed.

Mathematically, the probability that humans exist (denoted as m), and therefore may matter, is :

$$m = 10^{-200} \times 10^{-10} = 10^{-210} \tag{1}$$

This remarkably small value of m lends creedence to the fact that we may not be wholly irrelevant.

The Conditional Relations for the Anthropic Principle Proposed In the Extended Regime model (Model 2) pushes this argument even further. This new regime is one in which we take knowledge of the specialness of humankind and follow that semi-cogent path to uncover the specialness of *you*. We know that m is of order 10^{-210}, and now we fold in the probability that throughout all of humanity, *you* were created. We start by adding the simplified conjecture that every, and only, G-type stars have Earth-like planets that harbor human life ($\sim 10^{10}$ in our own galaxy), and that there are some $\sim 10^{10}$ MW-ish galaxies in our Universe. Armed with the knowledge that humans have been around $\sim 5999\frac{360}{365}$ years (see the previous section for the detailed calculation), let us postulate that over this time span there have been roughly 10^{10} human beings. Your parents were 2 of these 10^{10}, and there are $\sim 4.2817 \times 10^{22}$ genetically different zygotes for every couple. We define a new parameter ϵ with these considerations in mind,

$$\epsilon = \left(\frac{1}{10^{20}}\right) \times \left(\frac{2}{10^{10}}\right) \times \left(\frac{1}{4.2817 \times 10^{22}}\right), \tag{2}$$

What unfolds is quite remarkable, yet completely uncontrived. Close examination of Eq. 2 reveals that,

$$\epsilon = 4.6709 \times 10^{-53} \tag{3}$$

$$\epsilon = \frac{1.8439 \times 10^{-55}}{4\pi^2}, \tag{4}$$

which is just 42 times the Planck constant squared divided by $4\pi^2$:

$$\epsilon = 42 \times \frac{h^2}{4\pi^2} = 42\hbar^2, \tag{5}$$

Therefore, in units of $\hbar^{-2}$,

$$\epsilon = 42. \tag{6}$$

It may also be worth considering the interesting possibility that ϵ could evolve with time, making you even more special in the past (see Scherrer 2009). Of course, we need to combine ϵ and m to attempt to quantify your significance, thus we introduce the parameter u. There are surely other possibilities that could be considered, and we just add these as higher order terms O (naturally the uncertainties in the assumed WMAP5 parameters are encompassed by O). In other words,

$$u = \epsilon \times m + O, \tag{7}$$

(again, in units of $\hbar^{-2}$). The higher order terms can be set as an upper limit, thus we can re-write Eq. 7, which now says that,

$$u \leq m\epsilon, \quad \textbf{QED}. \tag{8}$$

Our theoretical argument certainly bolsters the Anthropic Principle. Specifically, the models imply that we as self-aware beings are special in the Multiverse, and possibly more importantly, that *you* are important, though $\leq m\epsilon$.

3. THE ACRONYM CLEVERNESS - NUMBER OF CITATIONS RELATION

While our rigorous mathematical proof in §2 appears infallible, Fig. 2 mandates that we proceed with caution, and that only time will tell how our theory holds up. In this figure we project where this paper will fall on the AC-NC diagram.
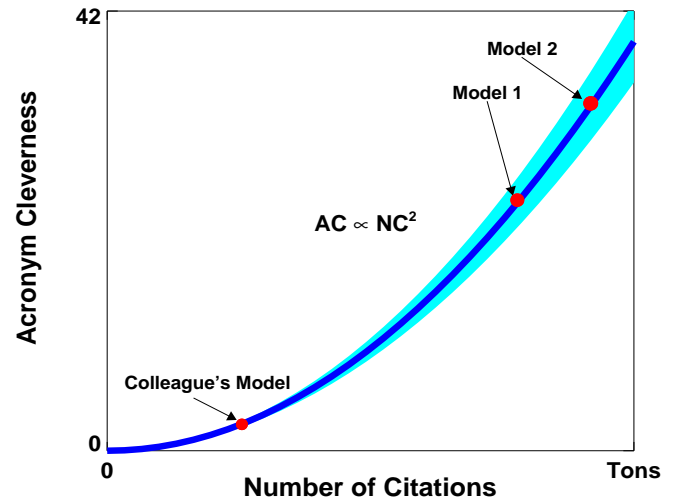

FIG. 2.— *AC-NC* diagram. We project where this paper will lie on the *AC-NC* relation. Solid band represents some sort of subjectiveness. Regardless of robustness, the weaker acronym for Model 1 has the potential to make our paper less relevant. We also show an anonymous colleague's model for comparison. See §2 for acronyms and details.

By standard convention, we investigate the power of our acronyms by making use of the Great Ramification Evaluator of Acronyms Tester (Jennings & Rutter 2011) – a modified version of the WÜRST test (Knack & Bier 1956). Since $AC \propto NC^2$, Model 1 has the potential to drive down the number of citations, and cause the paper (and hence our conjectures) to lose credibility. In fact, the previously published paper of the Probabilistic Evoking Of Non-essentiallity model (a colleague's model, not ours) actually uses our exact proof, essentially in reverse, to show that all of this conspiring actually proves that we are incredibly insignificant in what they dub "the grand scheme of things". Despite being far superior to our models and strongly suggesting our total lack of importance, their poor choice of acronym causes them to have an incredibly low citation count rendering their theory irrelevant. Some[3] have argued that the $AC - NC$ relation may be violated. To address this concern, in a forthcoming paper (Watson 2011, In Prep.) we develop the Conditional Relations for the Anthropic Principle for Probabilistic Informatic Extreme Set Theory model, which actually is only an acronym (a particularly clever one, and replete with big words) and should po-

tentially receive no citations, hence, violating the laws of Figure 2. Some concrete examples of the power of the AC-NC relation include BOSS (Eisenstein et al. 2011) and SHAM (Conroy et al. 2006). However, possible serious violations to consider are 2D-FRUTTI (Hesser et al. 1988) and PROSAC (Jørgensen et al. 2007) (see also; Bouvier et al. 1993; Jaffe et al. 1999; Miller et al. 2000; Corbett et al. 2001; Stern et al. 2002; Keating et al. 2003; Hill & Rawlings 2003; Seo et al. 2004; Beacom & Vagins 2004; Schenke et al. 2009; McBride 2011).

We conclude that time will tell whether or not you matter, however further consideration of the blatant circularity of this entire argument needs to be investigated, which has the potential to render this entire paper ipso facto meaningless.

4. ACKNOWLEDGEMENTS

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[3] Actually, no one

REFERENCES

Beacom, J. F., & Vagins, M. R. 2004, Physical Review Letters, 93, 171101
Bouvier, J., Cabrit, S., Fernandez, M., Martin, E. L., & Matthews, J. M. 1993, A&AS, 101, 485
Conroy, C., Wechsler, R. H., & Kravtsov, A. V. 2006, ApJ, 647, 201
Corbett, E., et al. 2001, in Astronomical Society of the Pacific Conference Series, Vol. 249, The Central Kiloparsec of Starbursts and AGN: The La Palma Connection, ed. J. H. Knapen, J. E. Beckman, I. Shlosman, & T. J. Mahoney, 126–+
Eisenstein, D. J., et al. 2011, ArXiv e-prints
Hesser, J. E., Smih, G. H., & Bell, R. A. 1988, JRASC, 82, 273
Hill, G. J., & Rawlings, S. 2003, New Astronomy Reviews, 47, 373
Jaffe, A. H., et al. 1999, in Astronomical Society of the Pacific Conference Series, Vol. 181, Microwave Foregrounds, ed. A. de Oliveira-Costa & M. Tegmark, 367–+
Jennings, K., & Rutter, B. 2011
Jørgensen, J. K., et al. 2007, ApJ, 659, 479
Keating, B. G., Ade, P. A. R., Bock, J. J., Hivon, E., Holzapfel, W. L., Lange, A. E., Nguyen, H., & Yoon, K. W. 2003, in Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series, Vol. 4843, Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series, ed. S. Fineschi, 284–295

Knack, & Bier. 1956
McBride, C. K. 2011, In Prep.
Miller, B. W., et al. 2000, in Astronomical Society of the Pacific Conference Series, Vol. 195, Imaging the Universe in Three Dimensions, ed. W. van Breugel & J. Bland-Hawthorn, 158–+
Schenke, B., Gale, C., & Jeon, S. 2009, Phys. Rev. C, 80, 054913
Scherrer, R. J. 2009, ArXiv e-prints
Seo, E. S., et al. 2004, Advances in Space Research, 33, 1777
Stern, D., et al. 2002, in Bulletin of the American Astronomical Society, Vol. 201, American Astronomical Society Meeting Abstracts, 603–+
Watson, D. F. 2011, The Anthropic Principle Journal, APJ
Zaius, D. R. 1968, Anthropic Principle Electronic Submissions, APES